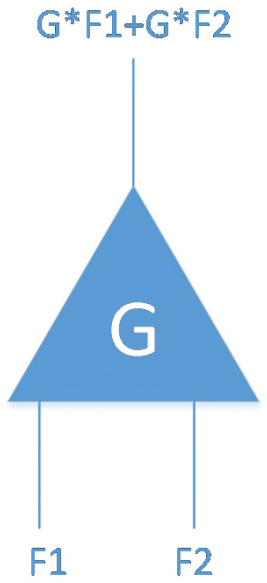
Downlink Interference Performance of Wideband Boosters

The Issue

- During FCC Part 20 rulemaking, a limit was defined for Input Intermodulation (IM)performance in both the uplink and downlink.
    - 47 CFR 20.21 (e)(8)(i)(F): -19dBm
- An equivalent Output Intermodulation limit was not set, as the main issue that was considered was the opportunity to generate uplink interference, and the -19dBm level achieved the goal of limiting uplink interference.
- Such an approach was possible, as the commission defined two categories of boosters: Consumer Signal Boosters and Industrial Boosters. The proposed IM rule would apply only to Consumer Signal boosters with Industrial Boosters requiring specific consent from the operator or a transmission license to operate (see Report and Order I-4 to I-6).
- Currently, the FCC is being requested to allow the use of Consumer Signal Boosters in Industrial Applications as well (Nextivity and Wilson Petitions).

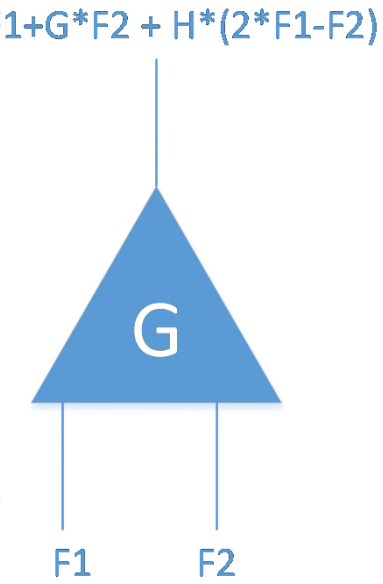
Wideband Boosters and Intermodulation

- Wideband Boosters by definition boosts all signals that fall within a band of operation, such as the PCS or AWS bands for example.
- The source of the signal being amplified is inconsequential – it can come from a base station, a handset or be an interfering signal.
- The biggest cause of interference in this respect for a Wideband Booster is Intermodulation.
- A perfect Wideband Booster will operate as follows
    - Signal on frequencies F1 and F2 are applied to input
    - Output contains sum of F1 and F2, multiplied by Gain



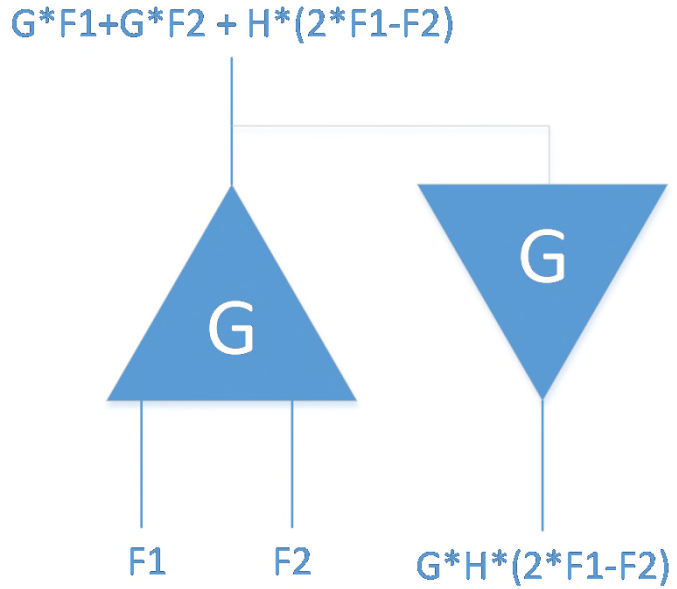
Wideband Boosters and Intermodulation

- A practical Wideband Booster will also generate Intermodulation components, giving an output of the wanted signal plus an interfering signal
    - In the example shown, a 3rd order IM component is shown.
- Based on 47 CFR 20.21 (e)(8)(i)(F), H*(2*F1-F2) must be less than -19dBm and the test is configured such that the intermodulation component (2*F1-F2) falls in the same transmit band as F1 and F2.
- The situation where the IM component falls in the paired downlink is not considered in the rules.
- For example, in the PCS band, consider a two signals with uplink frequencies of 1855MHz and 1905MHz. These two signal together will generate an IM signal at 2*1905-1855=1955MHz, which is in the downlink part of the PCS band.



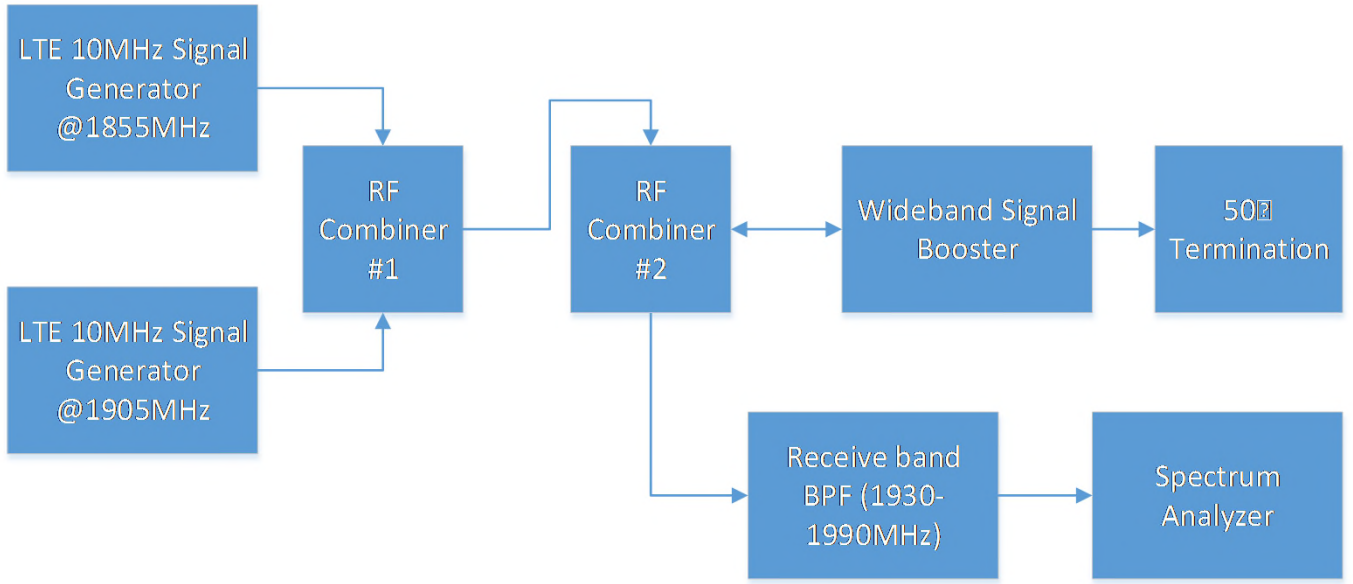
Wideband Booster and Intermodulation

- The downlink signal would then be amplified by the wideband booster and be a very strong interfering signal in the downlink direction.
- For example, if the IM level in the downlink band is -95dBm, it will be a strong interferer for any base station signal received by the wideband booster that is weaker than approximately -80dBm (essentially a very strong signal)



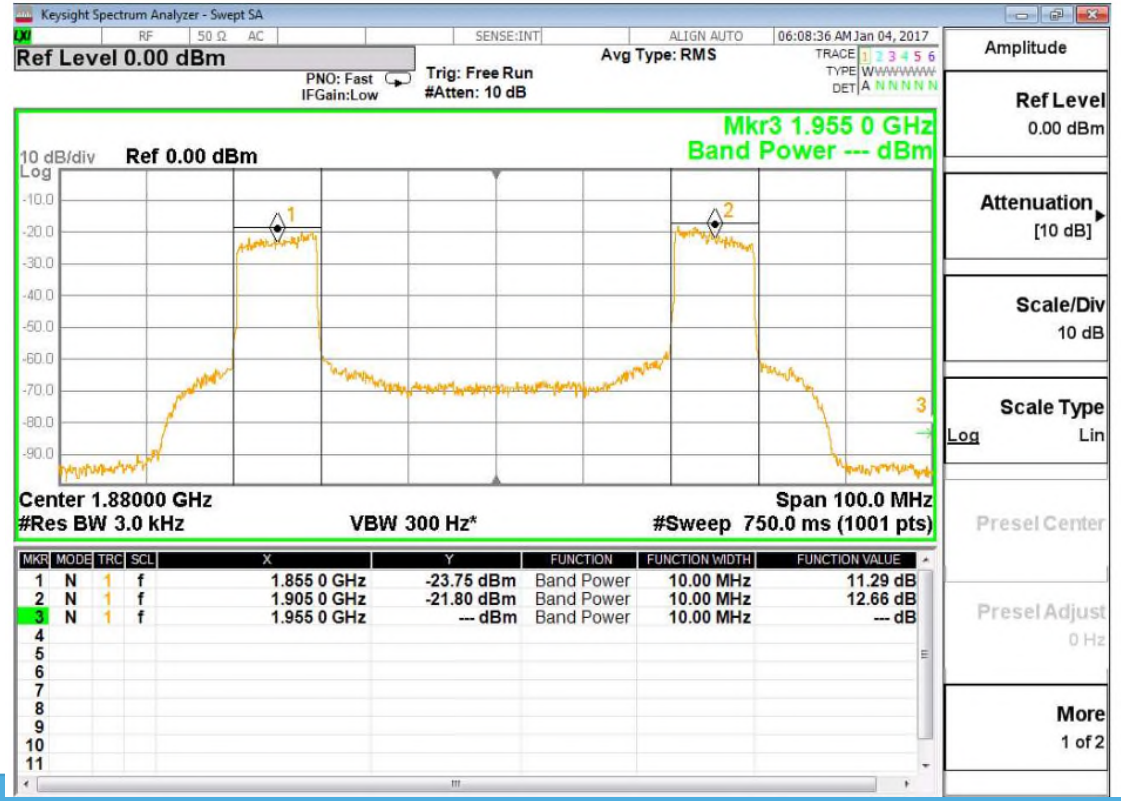
IM performance test setup

- Test setup
  - Two 10MHz LTE signal generators simulating LTE handsets transmitting in the uplink direction.
  - LTE signals combined in RF Combiner #1 (would happen over the air in a real installation)
  - RF Combiner #2 used to provide observing point for IM signal
  - Receive BPF used to filter out high powered LTE inputs to booster to prevent spectrum analyser overload.
  - Booster output terminated in perfect 50Ω load.
- Test procedure
  - Input combined LTE signals into booster
  - Allow booster gain to ramp as high as possible.
  - Monitor output of booster to be as close to max power as possible
  - Measure IM level of signal generated in the downlink



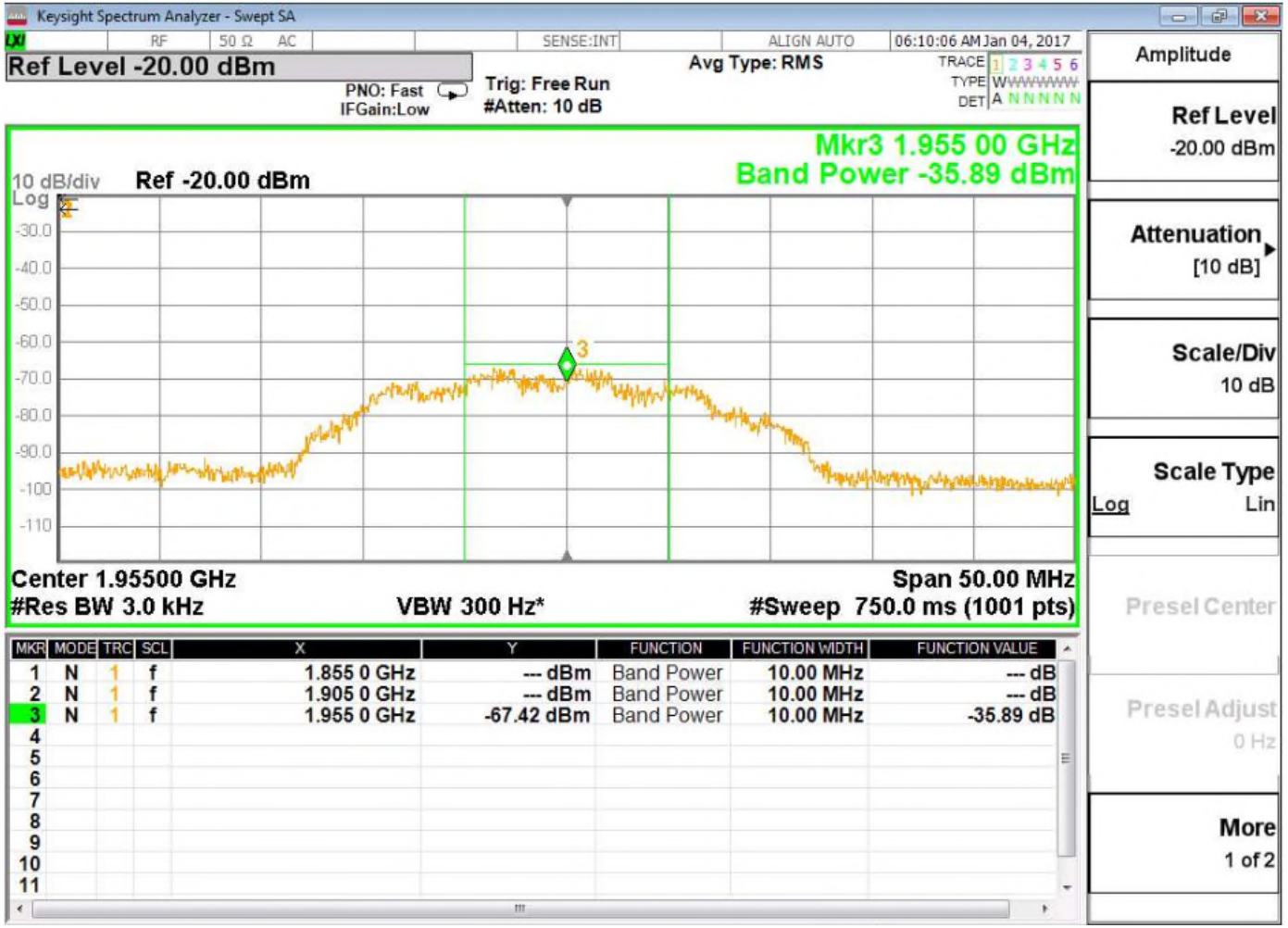
Measured Results – Wanted Booster Output

- Booster Output with -55dBm input signals (-52dBm total input power)
- Booster output approx. 15dBm
- Booster gain = 67dB
- Results taken with two commercially available Part 20 Wideband Consumer Signal Boosters.
- Only one set of results shown.



Measured Results – IM Output in Downlink

- Downlink interference at server output = -36dBm
- Level at donor port = -103dBm



Measured Results: Discussion

- The interference level at the Donor Input = -103dBm
- For better than 15dB SINR, input level @ 1955MHz must be >-88dBm
- Typical levels booster are used at is below -88dBm, hence a good chance that users on the 1955MHz channel will see very poor performance.
- Issue 1: Is it common to have two input signal levels @-55dBm?
    - YES, especially for LTE. LTE power control will ask handsets to increase power to max power (+23dBm) often as this will increase the SINR of the received signal in the uplink at the base station and improve uplink throughput. The improved uplink throughput enables more efficient use of spectrum.
    - With a UE at +23dBm, the input level will exceed -55dBm input level at the server antenna input at a distance of 25m, based on a standard indoor propagation model.
    - To create interference, two handset of two operators need to be doing uplink LTE transmissions within 25m from the server antenna. In a **PERSONAL USE** context, this is unlikely. In a **BUSINESS ENVIRONMENT**, this is much more likely, if not very likely to happen given the larger and more diverse handset population.
- Issue 2: Is it common to have donor signal levels of less than -88dBm?
    - YES. Based on field data or more than 2,000 booster installations, the probability of the input signal being below -88dBm is about 30%.
- Issue 3: Does the poorer SNR matter?
    - YES. The most likely outcome of this scenario is that users of the spectrum where the IM interference is present will see intermittent performance results from the booster. The installer would not know that the intermittent issue is caused by an IMD issue as it is a general consumer without training in RF installations (this is a Part 20 self-install device). The user will contact the operator whose signal is being jammed with a coverage complaint that is intermittent and the CMRS license holder will now have the burden to resolve this issue or have an unhappy customer.

Conclusion

- The PERSONAL USE restriction should not be lifted on Wideband Booster as they have a fundamental issue with Intermodulation performance creating downlink interference.
- Provider specific booster do not have this issue as they have zero gain in the downlink direction on the interfering frequency. For this reason, operators support the removal of the Personal Use restriction for Provider Specific Boosters.
- In order to remove the personal use restriction for Wideband Boosters, a requirement will need to be put in place to limit intermodulation interference in the downlink band. A reasonable number would be to limit it to at least 15dB below the minimum input level of the wideband booster.

Thank You

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